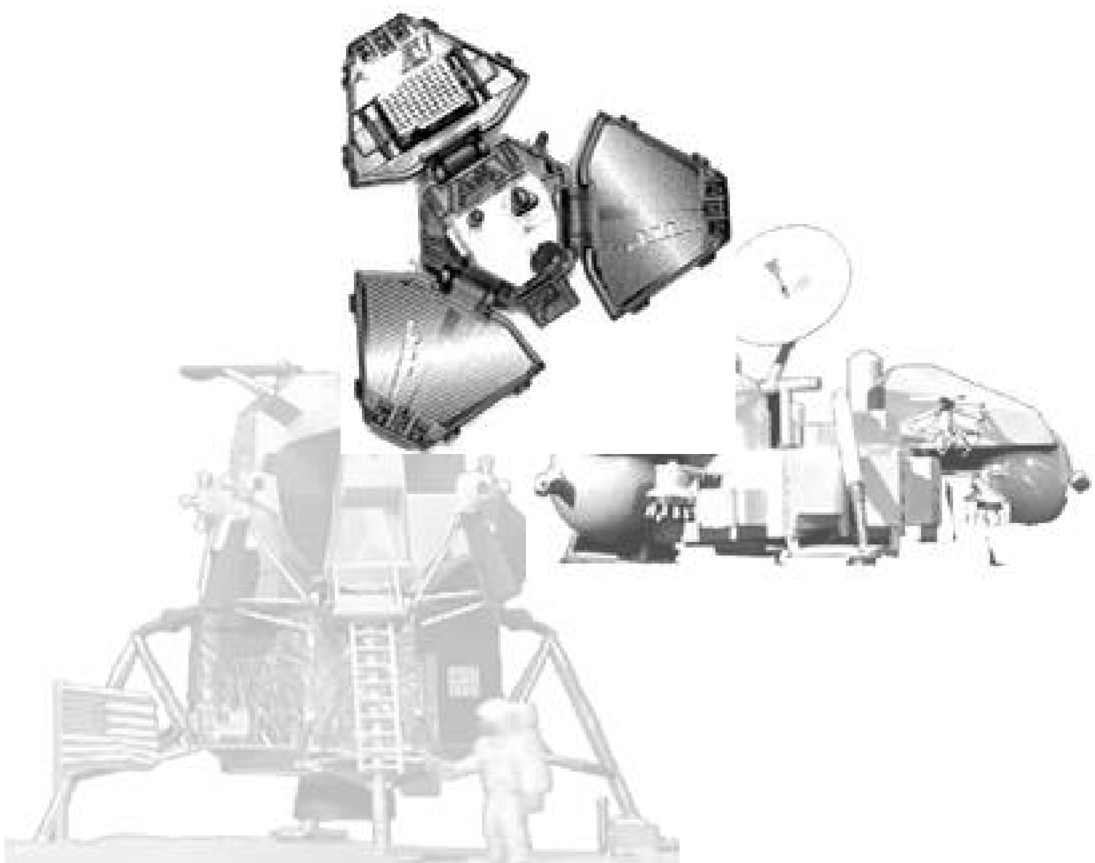
National Aeronautics and
Space Administration
Langley Research Center

Office of Education

Educator's Guide	
Teachers & Students	Grades K-8

CONNECT
VIDEO SERIES

Planetary Landers



Program 2 of 4

Publication Number
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Section 1

Background
(Pgs. 1, 2, 3, & 4)

- Introduction to CONNECT Series
- Introduction to Planetary Lander
- NASA's Contribution to Space Science

This section contains valuable information concerning the CONNECT Series and Planetary Lander, Program 2 of the CONNECT Series. This information will allow educators to become familiar with the purpose of the CONNECT Series and the Planetary Lander program and to understand the space science mission of the National Aeronautics and Space Administration (NASA).

Need More Copies?

We encourage the widest possible distribution and use of our educational programs and materials. Specifically, there is no claim of copyright by the U.S. government concerning the CONNECT Series. Therefore, our permission is not required to either tape each broadcast or to copy the associated print materials for classroom use and/or retention in your school's library.

NASA Strategic Plan identifies “Educational Excellence” as one of its strategic outcomes and states:

“We involve the education community in our endeavors to inspire America’s students, create learning opportunities, and enlighten inquisitive minds.”

NASA – Investing in America’s future through excellence in education

NASA is committed to promoting excellence in education, to supporting the teaching profession, and to increasing the awareness of the impact science, mathematics, and technology will have on the quality of life in the 21st century.

Call-In (for broadcast date only):
864-3991 (local) or
1-888-835-0026 (toll free)

E-Mail:
connect@edu.larc.nasa.gov

Web Site:
http://edu.larc.nasa.gov/connect/

INTRODUCTION TO THE CONNECT VIDEO SERIES

The CONNECT Video Series constitutes four, 30-minute interactive programs delivered to both K-4 and 5-8 audiences. Each program in the series will feature one of the four NASAStrategic Enterprises. It is this “content” that drives the uniqueness of the CONNECT programs. The Enterprises include Aeronautics and Space Transportation Technology, Human Exploration and Development of Space, Mission to Planet Earth, and Space Science.

SERIES OBJECTIVES

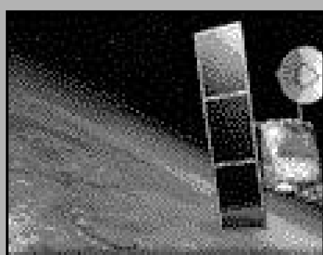
- Demonstrate the connection between the concepts and skills taught in the classroom and their application in the workplace.
- Address specific national mathematics standards and support state curriculum frameworks and standards.
- Actively engage students in problem solving, mathematical reasoning, and communicating mathematics.
- Build activities within the program’s design that encourage students to apply mathematical operations involving number sense and numeration, measurement, statistics and probability, and patterns and relationships.

ABOUT THE PROGRAM FORMAT

- NASAGuest: features a NASAengineer, scientist, or technician to illustrate the application of classroom lessons to the workplace
- Activities: involves the use of hands-on activities drawn from NASAeducational products and including the NCTM math activity books, *Mission Mathematics*, developed in collaboration with NASA
- Students: highlights elementary and middle school students and classrooms that have conducted the program’s experiment and shared the results with viewers
- Challenge Point: includes pause period whereby students are presented with data and, working in pairs or small groups, are encouraged to perform analysis and data interpretation
- Call, Write, Email-In: includes opportunity for students to call, write, or email before the program and following the Challenge Point portion of the program with questions related to the program topic, the activity, or to the guest
- Print Materials: provides registered educators with background on the program content, the guest, and the featured activity; materials include a master copy of Challenge Point worksheets for copying and distribution to students; and a listing of additional resources related to the program topic
- Web Site: enables viewers to register for the program, to download print materials, to post questions to the featured guest following the broadcast, to submit evaluation, and to acquire additional information

Sun-Earth Connection

Exploration of the Solar System



Structure & Evolution of the Universe

Search for Origins

INTRODUCTION TO PLANETARY LANDERS

NASA seeks to answer fundamental questions about the universe just as earlier astronomers did. However, NASA scientists have space-based telescopes, space probes, orbiters, and landers to explore the planets and to study the solar system. Engineers have the challenge to design a vehicle that meets the scientific requirements and that can place the lander safely onto a planet's surface.

In this program, students will explore the design considerations that go into constructing a planetary lander and will examine the mathematics behind the landing process. They will observe students conducting an experiment to investigate mass and velocity, in which different objects are dropped onto a "martian" surface. By working in pairs or small groups (during the program's Challenge Point), program viewers will better understand how research teams of NASAscientists, technicians, and engineers must work together to complete large projects involving planetary landers.

LEARN ABOUT NASA'S CONTRIBUTION TO SPACE SCIENCE

NASA's Space Science program includes four major science themes through which its research missions seek

- to better understand the Sun-Earth connection
- to explore the solar system
- to understand the structure and evolution of the Universe and to study the origin and distribution of life in the Universe
- to conduct an astronomical search for origins and planetary systems

Additional information on each of the four themes can be found on the NASASpace Science Home page at http://www.hq.nasa.gov/office/oss/index.html

The solar system is a science theme explored throughout one's educational experiences. Through NASA's exploration program, new information will continue to reshape the knowledge learned by students about the planets. So what might we expect from NASA's solar system studies? Below are NASA's goals for solar system exploration:

- Determine how our solar system formed and understand whether planetary systems are a common phenomenon throughout the cosmos.
- Explore the diverse changes that planets have undergone throughout their history and that take place at present, including those that distinguish Earth as a planet.
- Understand the processes that led to life on Earth and learn whether life began elsewhere in our solar system.
- Discover and investigate natural phenomena that occur under conditions not realizable in laboratories.
- Discover and inventory resources in the solar system that could be used by human civilizations in the future.
- Make the solar system a part of the human experience in the same way that Earth is, and hence lay the groundwork for human expansion into the solar system in the coming century.

At the **elementary and secondary levels**, NASA seeks to enhance the knowledge, skills, and experience of teachers and to capture student interest in science, mathematics, and technology through the demonstration of integrated applications of related subject matter.

NASA's science, mathematics, and technology education programs and activities leverage its inspiring mission, unique facilities, and specialized workforce.

MEET THE STUDENT HOST

VAN M. HUGHES

Van M. Hughes is a 14 year old freshman at Oscar Smith High School in Chesapeake, Virginia where he maintains an Aaverage. He also attends the Governor's School for the Arts and is a very promising actor. In addition to the CONNECT Series, Van starred in the 1996 NASA instructional video, *Think BIGG*. On weekends Van plays guitar and is the lead singer in his own young country teenage band ,"The Noodles."

MEET THE PROGRAM HOST

M. D. "SHELLEY" CANRIGHT, Ph.D.

Dr. M.D. "Shelley" Canright serves as Precollege Officer in the Office of Education at NASALangley Research Center, Hampton, Virginia. She is responsible for planning and implementing the Center's precollege educational programs and for the development of new products that integrate NASA's four enterprises with the national education goals and standards. Dr. Canright has 18 years of professional work experience in the field of education, spanning local (classroom and school board) to federal-level positions and experiences. Shelley has developed and managed a number of educational programs and projects that have received national recognition and awards, including a U.S. Presidential Letter of Commendation. Her doctorate in Instructional Systems, with a research interest in instructional television, makes her contributions to the ongoing development of the CONNECT Series invaluable.

MEET THE NASA GUEST ENGINEER

ROBERT D. "BOBBY" BRAUN, Ph.D.

Robert D. Braun is an aerospace technologist in the Space Systems & Concepts Division of the NASA Langley Research Center. His research interests focus on the development of aeroassist elements for robotic and piloted planetary exploration. Dr. Braun was a member of the Mars Pathfinder design team from 1992 to 1997, and he was the only non-Jet Propulsion Laboratory member of the Pathfinder entry, descent, and landing operations team. He led the LaRC Mars Pathfinder analysis efforts for which he received a NASAExceptional Achievement Medal and several NASA Group Achievement Awards. He also worked on the design of the New Millennium Mars Microprobes (scheduled for launch in January 1999). Dr. Braun is currently leading the Mars 2001 Atmospheric Flight Team; he is responsible for design of aerocapture and precision landing strategies for the Mars 2001 orbiter and lander. As a child, Bobby enjoyed building model rockets and flying radio controlled airplanes with his dad, a radio control airplane pilot. Bobby was also very active in sports, playing soccer, running cross country and bike riding. Today, when he takes time out from working and helping to raise his two children, he enjoys sailing and skiing.

To learn more about Bobby, visit his homepage at http://vab02.larc.nasa.gov/~rdb

Section 2

Pre-Program Preparation Activities (Pgs. 5, 6, 7, 8, & 9)

The information contained in this section is designed to prepare teachers and students for the (video) program. There are four pre-program, or preparation activities: (1) read aloud to the students the brief summary of "Meet The NASA Guest Engineer" on page 4; (2) display the *Mars Pathfinder: Roving on the Red Planet* poster and discuss with students what factors they think should be considered in designing a vehicle to descend from the atmosphere and safely land on another planet; (3) complete some of the activity suggestions listed on page 6; and (4) divide students into small groups or pairs in preparation for the Challenge Point period.

Mars Pathfinder Poster

- What mathematical information can be deduced from the diagrams?
- Convert the given measurement units to the same units.

Preparing for the Program

Display in the classroom the *Mars Pathfinder* poster that was distributed with the print materials. The poster is intended to generate interest about planetary exploration and to stimulate thinking about how one goes about designing a vehicle that will satisfy the scientific community's requirements and withstand the demands of space travel to entry, descent, and landing on another planet's surface.

A diagram of the dramatic entry, descent, and landing of the Mars Pathfinder is shown on the reverse side of the poster. Also shown is a diagram of the Mars Pathfinder Lander and its instrumentation. As part of the pre-program activities, educators may wish to make a xerox copy of this panel of the poster and reproduce it onto a transparency. Use this transparency for further discussion. What mathematical information can the students deduce from the diagrams?

During the video, the NASA guest will discuss the engineering process and the external factors (e.g., entry velocity, angle of entry, landing surface conditions) that needed to be pre-determined and factored into the overall design of the Mars Pathfinder vehicle.

Additional copies of the poster and other Mars materials distributed with this CONNECT guide can be obtained through the NASA Educator Resource Center. See Section 3, *Further Exploration*, for details.

Preparing for the Challenge Point

- Make copies of appropriate worksheet (Pgs. 8 & 9).
- Divide students into small groups or pairs.

Preparing for the Challenge Point Period

Prepare for the program's Challenge Point period, prior to the start of the program:

1. Make copies of the appropriate Challenge Point Worksheet and distribute one copy per student.
2. Divide students into small groups or pairs. Depending on the students, teachers may wish to do the Challenge Point as a large group.
3. Provide a calculator per group (optional).

BEFORE THE PROGRAM

The following suggestions will prepare the students for the program and help focus their attention on specific elements within the program's content.

VOCABULARY

1. Introduce the vocabulary terms: center of gravity (cg), mass, velocity, and weight.
2. Challenge students to consider the relationship between height and weight to cg, mass and velocity.

DISCUSSION QUESTIONS

List the following questions on the board. Have students discuss each question. Questions very similar to these will be asked of the featured guest. Following the program, go back to the questions and re-discuss.

1. What are some things that need to be considered before starting a design project?
2. What types of mathematics are involved in designing a space vehicle?
3. What applications in our everyday life can we find in the transfer of technology from the Mars Pathfinder program?

Consider listing the questions that other students ask during the program's call-in period. Have students re-examine those questions after the show as a review of what was presented. This review would be a great check for student understanding and a good lead into conducting the lesson activity, "Impact Craters" (See Section 4).

PLANETARY LANDER DESIGN ACTIVITY

This activity might be completed by students either prior to or after they have seen the *Mars Pathfinder* poster. Also, see Sections 3 and 4 for elaboration of this activity following the CONNECT program.

Make copies of the Planetary Lander Design Worksheet (See p. 7) and distribute one to each student. Instruct students to:

K-4: draw their version of a planetary lander

5-8: create a scale model drawing, including dimensions, of a planetary lander

CALL-IN/ E-MAIL OPPORTUNITY

Divide the class up into small groups and have each group come up with a list of questions they have about the program topic. Have groups share their group questions.

1. List each group's questions on the board and then select 2 to 3 questions from the list as a class.
2. Email these questions to CONNECT at: connect@edu.larc.nasa.gov

OR

3. Call-in with a question during the CONNECT call-in period: Toll Free 1 (888) 835-0026 Local 864-3991

Program Materials

- Challenge Point Worksheet
- Pencils
- Calculators (optional)

Technology Tip

Providing calculators for students to use may facilitate reasoning for students who have not mastered multiplication facts or division.

Program Vocabulary

- center of gravity (cg) - *A single point about which the mass of an object is considered to be centered*
- mass - *The amount of matter an object contains*
- velocity - *The speed and direction of an object's motion*
- weight - *The magnitude of a gravitational pull*

Planetary Lander Design Worksheet

____

(Vehicle Name)

Mission Purpose

____

____

____

Description

____

____

____

____

____

____

CHALLENGE POINT WORKSHEET
PRIMARY LEVEL (GRADES K-4)

Corporate Landing Elementary School Students' Impact Data

Crater Diameter

Object	Trial 1	Trial 2	Trial 3	Total	Average
A	4 cm	4 cm	4 cm		
B	5 cm	5 cm	5 cm	15 cm	
C	7 cm	5 cm	5 cm	17 cm	5.7 cm

1. Complete the chart for objects A and B.
   Hint: Total = Trial 1 + Trial 2 + Trial 3 *Average = Total ÷ Number of Trials*

2. Which object had the greatest mass? ______________________________

   Which object had the largest average? ______________________________

3. What do the data show about the relationship between the mass of an object to a crater's diameter?

   ____

   ____

   ____

4. If the objects were dropped from 2 times the drop height, would the crater diameter be larger or smaller? How much larger or smaller? Explain your answer.

   ____

   ____

   ____

CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (GRADES 5-8)

Kemps Landing Magnet School Students' Impact Data

Crater Diameter

	Drop Height = 30cm					Drop Height = 60cm				
Object	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average
A	4.0 cm	3.5 cm	3.5 cm			3.0 cm	3.0 cm	3.0 cm	9 cm	
B	3.5 cm	4.5 cm	3.5 cm			4.0 cm	4.5 cm	4.0 cm	12.5 cm	
C	5.0 cm	5.0 cm	5.0 cm	15 cm	5 cm	4.5 cm	5.0 cm	5.0 cm	14.5 cm	4.8 cm

1. Complete the chart for objects A and B. Round the average value to the nearest tenth.
   Hint: Total = Trial 1 + Trial 2 + Trial 3 *Average = Total ÷ Number of Trials*

2. What do the data reveal about the relationship between

   a) crater diameter to mass? ____

   ____

   b) crater diameter to velocity? ____

   ____

   c) crater diameter to an object's mass and velocity? ______________________________

   ____

3. Predict the crater diameter for each object if dropped from 3 times the maximum drop height.

   ____

   ____

   ____

4. What would happen if you change the angle of impact? How could this be tested?

   ____

   ____

   ____

Section 3

Viewing the Program

(Pgs. 10, 11, 12, 13, 14, 15, 16, & 17)

Viewing the Program

The Planetary Lander CONNECT program introduces students to the field of space science and engineering design by way of a dialog between the program host and a NASA researcher. The program highlights students conducting an experiment that simulates the impact of an object on a "Martian" surface. The experiment focuses on the relationship between an object's mass and velocity to the crater diameter that is created as a result of the object's impact on the landing surface. Data generated from the experiment will be displayed to the viewers, and viewers will be challenged to interpret and analyze the data during the program's Challenge Point Period.

Interactive Challenge Point

Challenge Point Period

This interactive program requires that each student record data on worksheets that are used during the program. Student worksheets and teacher answer keys are provided in this packet. Please note that there are worksheets and answer keys for K-4 and 5-8. Each CONNECT program is broadcast to two different audiences at two different times with modifications made to the experiment and presentation, as appropriate for the two audiences.

Grades K–4 Challenge Point

The **K-4** show and the Challenge Point will emphasize experimentation with one variable, *mass*. Students will examine the relationship of the mass of an object to crater diameter. Students will work with trial data to find the total value and average for the trials. Number sense and numeration, measurement, and patterns and relationships will be emphasized.

Grades 5-8 Challenge Point

The **5-8** show and the Challenge Point will emphasize two variables, *mass* and *velocity*, and the relationships of mass and velocity of objects to crater diameter. Students will compute the average and analyze the data comparing objects of different mass that are dropped from varying heights. Number sense and numeration, measurement, statistics and probability, and patterns and relationships will be emphasized.

Further Extensions

Further extensions to the program and additional Mars and Space Science resources are outlined on pages 14–17.

Evaluation Form

http://edu.larc.nasa.gov/connect/evaluation.html

What did you think of Planetary Lander, CONNECT Program 2? Please complete the enclosed postage-paid evaluation card. Or, to send us your comments electronically, go to http://edu.larc.nasa.gov/connect/evaluation.html

NCTM Standards

- Number Sense and Numeration
- Measurement
- Statistics and Probability
- Patterns and Relationships

Program Objectives

- Conduct experiment: collect, organize, display and interpret data
- Find the average
- Work cooperatively in pairs/teams

Challenge Point Assessment Tip

- Observe which students can use a data-collection form and which students need to learn how
- Talking and writing about solutions helps students confirm their learning

THE PROGRAM CHALLENGE POINT

Built within the program's design is a pause period (approximately 4 minutes long) where students will be asked to look at generated data and, working in pairs or small groups, respond to questions, one at a time, as listed on the Challenge Point Worksheet (See p. 8 [K-4] & p. 9 [5-8]). This pause period is important for providing students the opportunity to work with information presented up to this point and to actively examine and work with data in support of the NCTM standards.

DURING THE CHALLENGE POINT PERIOD

Teacher as Facilitator

Built within the program's design is a pause period where students will be asked to look at data and, working in pairs or small groups, respond to questions and complete tables or graphs detailed on the Challenge Point Worksheet.

1. Make copies of the Challenge Point Worksheet and distribute one copy per student before starting the program.
2. Depending on your students, teachers may wish to do this as a large group or divide students into pairs or smaller groups. This grouping should be done in advance of the program.
3. The teacher is to act as a facilitator during this program time, supporting and guiding the students in discussion and in responding to the worksheet questions.

Student as Researcher

By working in pairs or small groups, students will better understand how NASA research teams must work together to analyze and interpret findings and to communicate results in written, oral, and graph forms.

1. Observe the data shown on the television, as recorded by the featured school and as displayed on the worksheet.
2. Questions pertaining to the data will be presented one at a time on the video. You will have a limited amount of time to discuss the question with your partner(s), calculate an answer, if necessary, and write down a response.
3. Feedback to the questions will be presented to you at the end of the Challenge Point period. Review your answers. Following the program, continue your discussions if necessary.

CHALLENGE POINT WORKSHEET
PRIMARY LEVEL (GRADES K-4)
ANSWER KEY

Corporate Landing Elementary School Students' Impact Data

Crater Diameter

Object	Trial 1	Trial 2	Trial 3	Total	Average
A	4 cm	4 cm	4 cm	12 cm	4 cm
B	5 cm	5 cm	5 cm	15 cm	5 cm
C	7 cm	5 cm	5 cm	17 cm	5.7 cm

1. Complete the chart for objects A and B.
   Hint: Total = Trial 1 + Trial 2 + Trial 3 *Average = Total ÷ Number of Trials*

2. Which object had the greatest mass? *Object C had greatest mass*

   Which object had the largest average? *Object C had the largest average*

3. What do the data show about the relationship between the mass of an object to a crater's diameter?
   The larger the mass of an object, the larger the crater's diameter

4. If the objects were dropped from 2 times the drop height, would the crater diameter be larger or smaller? How much larger or smaller? Explain your answer.
   The crater diameter would be larger. Dropping from 2 times the drop height increases the distance and speed which the object falls. The object hits the surface harder and makes deeper impression and greater crater diameter.

CHALLENGE POINT WORKSHEET
INTERMEDIATE LEVEL (GRADES 5-8)
ANSWER KEY

Kemps Landing Magnet School Students' Impact Data

Crater Diameter

	Drop Height = 30cm					Drop Height = 60cm				
Object	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average
A	4.0 cm	3.5 cm	3.5 cm	11 cm	3.7 cm	3.0 cm	3.0 cm	3.0 cm	9 cm	3 cm
B	3.5 cm	4.5 cm	3.5 cm	11.5 cm	3.8 cm	4.0 cm	4.5 cm	4.0 cm	12.5 cm	4.2 cm
C	5.0 cm	5.0 cm	5.0 cm	15 cm	5 cm	4.5 cm	5.0 cm	5.0 cm	14.5 cm	4.8 cm

1. Complete the chart for objects A and B. Round the average value to the nearest tenth.
   Hint: Total = Trial 1 + Trial 2 + Trial 3 *Average = Total ÷ Number of Trials*

2. What do the data reveal about the relationship between

   a) crater diameter to mass? *Larger the mass, larger the crater diameter*

   b) crater diameter to velocity? *Greater the velocity, greater the crater diameter*

   c) crater diameter to an object's mass and velocity?

   The greater the mass of an object and the velocity that it travels, the larger the crater's diameter upon impact of object upon (flour/ jello mix) surface.

3. Predict the crater diameter for each object if it is dropped from 3 times the maximum drop height.

   Answers will vary.

4. What would happen if you change the angle of impact? How could this be tested?

   Answers will vary.

NASA's Education Program is guided by its **Strategic Plan for Education** and is carried out through its nine field centers and the Jet Propulsion Laboratory.

Education programs are grouped into six general categories:

- Teacher/Faculty Preparation and Enhancement Programs
- Curriculum Support & Dissemination Programs
- Support for Systemic Change
- Student Support Programs
- Educational Technology Programs
- Mission, Research & Development, and Operations Programs

NASA Education Link:

http://www.hq.nasa.gov/education

NASA Langley Office of Education Web Site:

http://edu.larc.nasa.gov/

FURTHER EXPLORATION

1. Complete the **Planetary Lander** activity contained in the Appendix. This activity has been modified from the NASA educational product, *Exploring The Moon: A Teacher's Guide with activities for Earth and Space Sciences* (EP-306, Sept. 1994). This product is available through the NASAEducator Resource Center Network (See item 4, below).

2. **Land ahoy!** Challenge students to design and build a model craft that could land on a planet and gather information. This is an excellent team-building, cooperative learning activity.

   Week 1: Divide class into teams and give each team a week to design a crewless craft that could land on a planet. Encourage teams to divide responsibilities and resist supplying them with answers. Have teams turn in a paper version of their proposed design.

   Week 2: Teams build a scale model of their proposed craft using inexpensive and recycled materials.

   Week 3: Test the landers. Help teams locate a test site where they can safely drop the landers from a height of 20 feet or more. Does it land without damage? If it is damaged, analyze what went wrong. Rebuild or repair the landers and test again.

   Extension: Assign teams to select a test site but tell them to keep the location secret. Have them collect samples and photos from the site. When the class meets, the teams can take turns sharing their samples. Members of the other teams can try to describe the site based on the samples and, perhaps, guess its location.

   NCTM Assessment Standard: Each team can report its findings and conclusions orally to the class. This oral report gives students an opportunity to plan and rehearse a group presentation. Allow students to enhance their understanding of using graphs as a tool for communicating by reporting their findings. Make the assessment an open process by having students help create a checklist as they prepare and rehearse their presentation.

3. Explore the following web sites for online projects and activities that connect with the study of Mars and space science:

   Kid's Space http://liftoff.msfc.nasa.gov/kids/welcome.html

   Contains activities for a younger audience. Students can do interactive word find puzzles, an activity where they find out what their weight would be on another planet, and a quiz that prints out a certificate of completion when the student has finished.

Live From Mars
http://quest.arc.nasa.gov/mars/

By participating in the *Live from Mars* project, you and your students can join the Mars team in their exploration of the Red Planet! The project is targeted at the middle school grade levels but will have appeal above and below that range.

4. On-Line Resources for Students and Educators

Visit the NASA Home Page and Office of Space Science Home Page:

NASA Home Page
http://www.nasa.gov/

NASA Office of Space Science
http://www.hq.nasa.gov/office/oss/osshome.htm

Check out some of the following Mars Web Sites:

Ames Center for Mars Exploration
http://cmex-www.arc.nasa.gov

"Images of Mars" (Space Telescope Science Institute)
http://marvel.stsci.edu/exined-html/Mars.html

Lunar and Planetary Institute
http://cass.jsc.nasa.gov/expmars/expmars.html

Mars Pathfinder Project
http://mpfwww.jpl.nasa.gov

Mars K-12 Curriculum Guide (Arizona State University)
http://esther.la.asu.edu/asu_tes/TES_Editor/CURRIC_GUIDES/curric_guideMENU.html

Mars Resources
http://k12unix.larc.nasa.gov/mars/teachersguide/MarsResources.html

Viking Orbiter Image Archive
http://barsoom.mss.com/http/vikingdb.html

Viking Lander Image Data
http://www-pdsimage.jpl.nasa.gov/PDS/public/viking/vl_images.html

NASA Education Links:

Education Home Page
http://www.hq.nasa.gov/education

Jet Propulsion Laboratory
http://learn.jpl.nasa.gov

Spacelink
http://spacelink.nasa.gov

Space Science Education/Public Outreach Sites
http://www.hq.nasa.gov/office/oss/education/edsites.htm

5. Mars Educational Products available from NASA Educator Resource Centers (ERC)

Below are sample educational products available to educators. Contact the NASAERC that services your state:

Educational Brief
Exploring Mars (EB-1997-01-120-HQ)

Posters
Postcards from...Mars (EW-1997-02-127-HQ)
Mars Pathfinder--Roving the Red Planet (EW-1997-08-128-HQ)

Lithograph Set
Mars Pathfinder Sojourner Return

Slide Sets
Mars Pathfinder/Sojourner: Success, July 1997
Mars Pathfinder/Sojourner Return to the Red Planet

Contact information about the NASA ERCs, regarding their locations, addresses and telephone numbers can be found at:
http://www.teacherlink.usu.edu/nasa/accessnasa/TRC.html

NASA ERC serving Langley's 5-state service region of KY, NC, SC, VA, and WV:

Virginia Air & Space Center
NASA Langley Educator Resource Center
600 Settlers Landing Road
Hampton, VA 23669-4033
(757) 727-0900, ext. 757
http://www.vasc.org/erc/

6. Leap into more space science-related mathematics activities from the National Council of Teachers of Mathematics (NCTM) and the NASA-funded product, *Mission Mathematics, Linking Aerospace with the NCTM Standards.*

   Mission Mathematics

   • integrates mathematics and science following the guidelines of the NCTM standards

   • motivates students to explore math and develop mathematical thinking

   • features activity books and posters for grades K-6, 5-8, and 9-12

   Contact the NCTM, 703/620-9840, for more information, or visit their web site at http://www.nctm.org/

7. *Craters! A Multi-Science Approach to Cratering and Impacts*, a joint project of NSTA, NASA, and the Planetary Society. Make an impact in your classroom with this interdisciplinary guide to cratering. *Craters!* includes 20 ready-to-use, hands-on activities that use cratering to teach key concepts in physics, astronomy, biology, and Earth sciences. Special features include a custom CD-ROM packed with supplemental images for classroom activities, a specially written summary of research on Shoemaker Levy 9's encounter with Jupiter, and a detailed background section for teachers. Includes Mac/Windows CD-ROM.

   Contact the NSTA Special Publications, 800/722-NSTA, for more information on *Craters!* (ISBN: 0-87355-132-X), or visit their web site, at http://www.nsta.org/

Section 4

Planetary Lander Classroom Experiment Self-Contained Lesson

The following lesson plan will allow your students to duplicate the experiment that was shown during Planetary Lander, Program 2 of the CONNECT Series. Copies of the video can be made at the NASA Langley Educator Resource Center.

Nick Kolten, ERC Manager
Virginia Air & Space Center
NASA LaRC ERC
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INTRODUCTION

NASA seeks to answer fundamental questions about the universe just as earlier astronomers did. However, NASAscientists have space-based telescopes, space probes, orbiters, and landers to explore the planets and to study the solar system. Engineers have the challenge to design a vehicle that meets the scientific requirements and that can place the lander safely onto a planet's surface.

In this lesson, students explore the design considerations that go into constructing a planetary lander and examine the mathematics behind the landing process. They will conduct an experiment to investigate mass and velocity in which different objects are dropped onto a "Martian" surface. By working in pairs or small groups, they will better understand how research teams of NASA engineers, scientists, and technicians must work together to complete large projects involving planetary landers.

In this activity, the students will experiment by using various spheres such as golf balls, ping pong balls, or super balls as impactors. As the balls are dropped (K-4, one height; 5-8, two heights) onto a prepared "Martian" surface, the students observe and record the resulting impact (crater size). Students determine the crater size (diameter and depth) of the 3 impacts and compute the average over 3 trials.

PURPOSES

- to determine the factors affecting the crater size
- to collect and interpret data
- to compute the average of the test data
- to make and test predictions about the effects of impactors on a target surface
- to suggest future experiments to test impactors

NCTM STANDARDS

- Statistics and Probability
- Number Sense and Numeration
- Patterns and Relationships
- Measurement

NCTM ASSESSMENT STANDARDS

- Observe which students can use a data-collection form and which students need to learn how
- Talking and writing about solutions helps students confirm their learning

INSTRUCTIONAL OBJECTIVES

- Conduct experiment: collect, organize, display, and interpret data
- Find the average
- Work cooperatively in pairs/teams

PREREQUISITE MEASUREMENT AND GEOMETRY CONCEPTS

Students should be able to

- Understand metric units
- Use and read a ruler
- Understand the words diameter, depth, and average

EXPERIMENT MATERIALS

Pan, "Martian" surface material (flour, baking soda, sand, or corn meal, dry tempera paint [optional]), 3 impactors of same size but different mass (golf, ping pong, and super balls), metric ruler, balance, calculators (optional)

PRINT MATERIALS

- Mars Pathfinder poster
- Impact Crater Data Sheet
- Planetary Lander Design Sheet

MANAGEMENT TIP

This activity is intentionally planned to take several periods. Determine the number and duration of sessions and the appropriate level of instruction for your class.

TECHNOLOGY TIP

Providing calculators for students to use may facilitate reasoning for students who have not mastered multiplication facts or division.

GETTING STARTED

Make a transparency of and show your class the diagram of the dramatic entry, descent, and landing of the Mars Pathfinder on the reverse side of the *Mars Pathfinder* poster. Present the following background information:

> The circular features so obvious on Mar's surface are impact craters formed when objects (impactors) smash into the surface. Similar to an impactor, a planetary lander may create craters in the process of landing. Impact craters are found on all the terrestrial planets and on many moons of the outer planets. The explosion and excavation of material at the impacted site create piles of rock around the circular hole as well as bright streaks of target material thrown for great distances. By studying all types of craters on Earth and by creating impact craters in experimental laboratories, scientists can conclude which are impact craters in origin. There are many factors affecting the appearance of impact craters and the resulting crater diameter and depth.

The following experiment simulates the formation of craters by impactors and shows the effect of the two variables, mass and velocity on the created crater. Students in grades **K-4** will examine the relationship of the *mass* of an object to crater size (crater diameter and depth). Students in grades **5-8** will examine relationship of *mass* and *velocity* to crater size. All students will work with the trial data to find the total value and the average of crater diameter and depth for each impactor.

VOCABULARY TERMS

- Center of Gravity: a single point about which the mass of an object is considered to be concentrated
- Mass: the amount of matter an object contains
- Velocity: the speed and direction of an object's motion
- Weight: the magnitude of a gravitational pull

CLASS DISCUSSION

Display the *Mars Pathfinder* poster in the classroom to generate interest about planetary exploration and thinking about the process of designing a vehicle and landing it on a planetary surface.

1. What are some things that need to be considered before starting a design project?
2. What types of mathematics do you think are involved in designing a space vehicle?
3. What applications in our everyday life do you think might benefit from the transfer of knowledge gained from the research with the Mars Pathfinder program?

BEFORE THE ACTIVITY

Prepare the “Martian” surface. Any of the following materials will work well as a base for the "Martian” surface topped with a dusting of red jello mix or other material in a contrasting color:

- all purpose flour - reusable in this activity and keeps well in a covered container.
- baking soda - reusable in this activity, even if colored, by adding a clean layer of new white baking soda on top. Keeps indefinitely in a covered container.
- sand and corn starch - mixed (1:1); sand must be very dry. Keeps only in freezer in airtight container.
- dry tempera paint or powdered drink and jello mixes or glitter - sift on top; use a sieve, screen, or flour sifter. A contrasting color to the base materials gives striking results.

Pans should be plastic, aluminum, or cardboard. Basic 10"x12" pans or plastic tubs work fine, but the larger the better to avoid misses. Also a larger pan may allow students to drop more impactors before having to resurface the target materials. Fill the pan with surface material to a depth of about 2.5 cm.

Make copies of the **Impact Craters Data Chart** and distribute one to each student.

DEVELOPING THE ACTIVITY

Planetary Lander Design Activity

This activity might be completed by students either prior to or after being shown the *Mars Pathfinder* poster. Also, see Further Exploration for elaboration of this activity.

Make copies of the Planetary Lander Design Worksheet and distribute one to each student. Instruct students to:

- K-4: draw their version of a planetary lander
- 5-8: create a scale model drawing, including dimensions, of a planetary lander

Class Discussion

- Look at your lander design and consider the landing process and the impact on the surface.
- How might your lander enter, descend, and land?
- How could the impact be minimized?

Planetary Lander Activity

Grades K-4

Divide the students into teams of 2 to 4 members. Distribute a “Martian” surface pan to each team and a copy of the Challenge Point Worksheet to each student.

Instruct the students to work as a team and assign the following responsibilities: (1) weigh and record the mass of each impactor in grams, (2) drop the impactor on the "Martian" surface, (3) measure the crater size, (4) record the data, and (5) "smooth" and resurface the material in the pan.

Weigh each impactor and record. Starting with a smooth surface, the first impactor is dropped 3 times on the "Martian" surface from a distance of 30 cm. The crater's diameter and depth are measured and the data recorded. The surface is smoothed and the second impactor is dropped 3 times and the data recorded. The same procedure is repeated with the third impactor. The members of the team then complete the total and average values for impactors A, B, and C. After all teams have completed this activity, bring the class together to discuss their findings. Refer to grades K-4 questions.

Grades 5-8:

Follow directions as outlined above. However, students in grades 5-8 will drop the impactors at 3 different heights: 30 cm, 60 cm, and 90 cm. The total and average values of the crater diameter and depth created by each impactor at each height is computed. Ask students to write responses to the 5-8 Questions using their data. Discuss.

Management Tips

During this activity, the “martian” surface particles may fall onto the floor. Spread newspapers under the pan(s) to catch spills or consider doing the activity outside.

Have the students agree beforehand on the method they will use to "smooth" and resurface the material in the pan between impacts. The material need not be packed down. Shaking or tilting the pan back and forth produces a smooth surface.

Remind students that better experimental control is achieved with consistent handling of the materials. For instance, cratering results may vary if the material is packed down for some trials and not for others.

CLASS DISCUSSION

Grades K-4 Questions

- Which object had the greatest mass?
- Which object had the largest average?
- What do the data show about the relationship between the mass of an object to a crater's size?
- If the object were dropped from 2 times the (30 cm) drop height, would the crater size be larger or smaller? How much larger or smaller? Explain your answer. How could this be tested?

- What other experiments might be conducted with these test materials?

Grades 5-8 Questions

- What do the data reveal about the relationship between
  a) crater size to mass?
  b) crater size to velocity?
  c) crater size to an object's mass and velocity?
- Predict the crater diameter for each object if dropped from 3 times the maximum drop height.
- What would happen if you changed the angle of impact? How could this be tested?
- What other experiments might be conducted with these test materials?

FURTHER EXPLORATIONS

- **Planetary Lander Design Worksheet**

  K-4: After drawing lander, have students identify and describe geometric figures represented. Sort and classify objects by shape and size.

  5-8: Have students sketch lander model on graph paper. Challenge students to apply transformations to model.

- **Impact Crater! Experiment**

  K-4: Display objects and information using object and pictorial graphs and table.

  5-8: 1. Find the mean, median, and mode of set of data and determine their meaning for the set of data.

  2. Collect, organize, and display set of data in variety of forms.

  3. Find the circumference and area of circle given the diameter.

- **Land ahoy!** Challenge students to design and build a model of a craft that could land on a planet and gather information. This exercise is an excellent team-building, cooperative learning activity.

  Week 1: Divide class into teams and give each team a week to design a crewless craft that could land on a planet. Encourage teams to divide responsibilities and resist supplying them with answers. Have teams turn in a paper version of their proposed design.

  Week 2: Teams build a scale model of their proposed craft using inexpensive and recycled materials.

  Week 3: Test the landers. Help teams locate a test site where they can safely drop the landers. Does it land without damage? If it is damaged, analyze what went wrong. Rebuild or repair the landers and test again.

  Extension: Assign teams to select a test site but tell them to keep the location secret. Have them collect samples and photos from the site. When the class meets, the teams can take turns sharing their samples. Members of the other teams can try to describe the site based on the samples and, perhaps, guess its location.

  NCTM Assessment Standard: Each team can report its findings and conclusions orally to the class. This oral report gives students an opportunity to plan and rehearse a group presentation. Allow students to enhance their understanding of using graphs as a tool for communicating by reporting their findings. Make the assessment an open process by having students help create a checklist as they prepare and rehearse their presentation.

Impact Crater Data Chart (Grades K-4)

Name ______________________________ Date ______________________________

Impactor # _____

______ gm

	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					

Impactor # _____

______ gm

	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					

Impactor # _____

______ gm

	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter					
Crater Depth					

Impact Crater Data Chart
(Grades 5-8)

Name ____________________________ Date ____________________________

	Drop Height = 30 cm					Drop Height = 60 cm					Drop Height = 90 cm				
_____ gm	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter															
Crater Depth															

_____ gm	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter															
Crater Depth															

_____ gm	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average	Trial 1	Trial 2	Trial 3	Total	Average
Crater Diameter															
Crater Depth															

EVALUATION FORM

WHAT DID YOU THINK OF CONNECT: PLANETARY LANDERS?

Please take a few minutes to respond to the following questions.

School ___________________________________ School Division_____________________________________

Grade Level / Subject ______________________ No. of students participated in program _____________

	Not at all		Somewhat		To a great extent
1. The program was valuable to					
a. your students	1	2	3	4	5
b. yourself as a teacher	1	2	3	4	5
2. The written materials were valuable to					
a. your students	1	2	3	4	5
b. yourself as a teacher	1	2	3	4	5
3. The program met your expectations?	1	2	3	4	5
4. Did you view the program					
a. live	Yes		No		
b. videotape	Yes		No		

5. What comments or suggestions do you have for the program?

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Thank you for your response.

Please fax evaluation form to: (757) 864-8835 or Mail to:

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